DESCRIPTION

OF A NEW

CATALOGUING AND CHARTING MACHINE.

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ART. IX. *Description of a New Machine for Cataloguing and Charting Stars*, by G. W. HOUGH, A. M.

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The progress of Instrumental Astronomy has been so rapid during the last half century, not only in the perfecting of the older instruments, but also in the invention of new methods of observation, that at the present time more can be accomplished in one year than could formerly have been done in two.

In the year 1848, the application of Electricity to the recording of Astronomical Observations was first suggested. This happily conceived idea soon resulted in the construction of Chronographs by various persons, by which the instant of transit of a star was accurately recorded in a legible and permanent manner. Success in the recording of one ordinate of a star's position would naturally suggest the possibility of fixing the other by the same agency. But with the exception of some experiments made by the late Prof. O. M. Mitchel for the recording of declinations by electricity, this subject, so far as I know, has not been undertaken by any other astronomer.

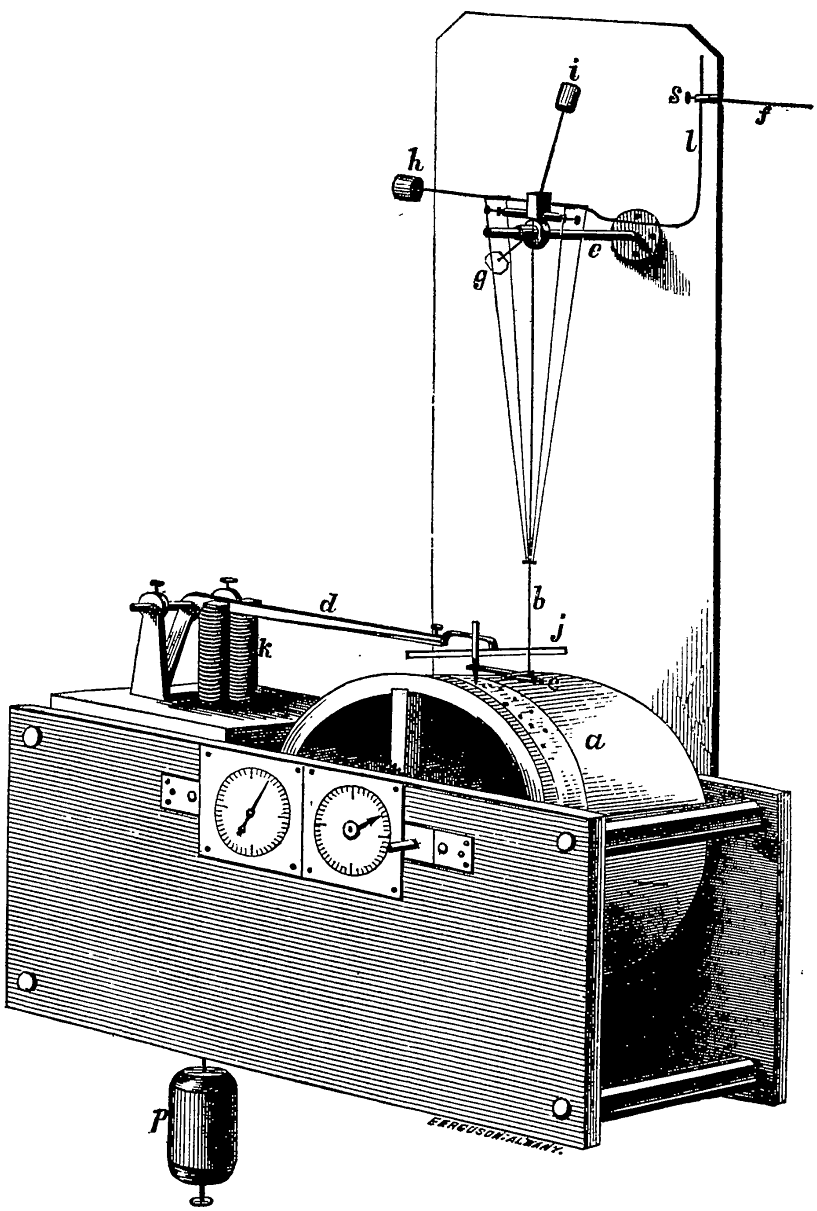
In the formation of catalogues of zone stars, astronomers have almost invariably used the Telescope in a fixed position, and, by means of a diaphragm or scale placed in the focus, determined the time of transit and difference of declination. In our method, the Telescope is moved in zenith distance, the amount of motion giving us the difference of declination.

This method of observing the difference of declination between two objects, by magnifying by mechanical means the angular motion of the Telescope, is due to the late Prof. O. M. Mitchel, who first put it in practical operation in the year 1849; the apparatus used for this purpose

pulleys attached directly to the screw, we know the error would be still less. From this fact, we were led to surmise, that difference of declination could easily be read to the tenth of a minute, from a screw head used for giving slow motion to the Telescope.

In thinking on this subject, I conjectured that if a cylinder were attached to this screw, and a pen be made to

Fig. 1.



move over it with a uniform velocity in the direction of its length, we could readily record both Right Ascension

and Declination, or, in other words, make a map of the stars observed. Owing to inconvenience in attaching such an apparatus to our instrument, the plan was not put in execution.

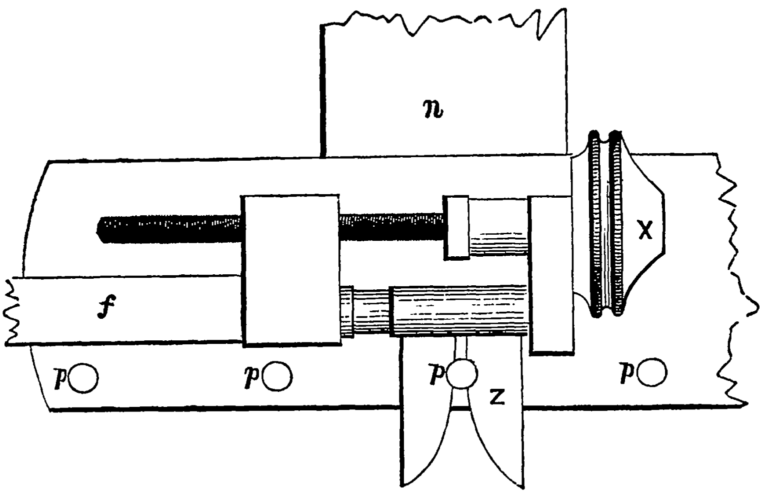
We will now proceed to give a description of the Charting Machine. Fig. 1 is a perspective of the machine, as seen from the southeast.

This apparatus is firmly fastened to the south side of the west pier. It is connected with the clamp arm of the Telescope by means of the horizontal rod (*f*), 40 in. in length.

A clock work mechanism, having a half second's pendulum (*p*), carries the cylinder (*a*), 6 in. in length and 10 in. in diameter; which revolves from west to east, and makes a complete revolution every hour.

Directly over the cylinder is mounted, on a horizontal axis, the compound lever (*b*, *l*); to the lower end of which, by means of a short horizontal arm and joint, a pencil is held in a vertical position over the axis. The lower part of this lever (*b*), is 18 in. long; the upper part (*l*) is 6 in. long. In order to magnify as much as possible the angular motion of the clamp arm, we attach to it a strong iron bar, 25 in. in

Fig. 2.



length. At the lower end of this bar is a cross piece, fig. 2, 6 in. long, holding a number of cylindrical pins (*p*).

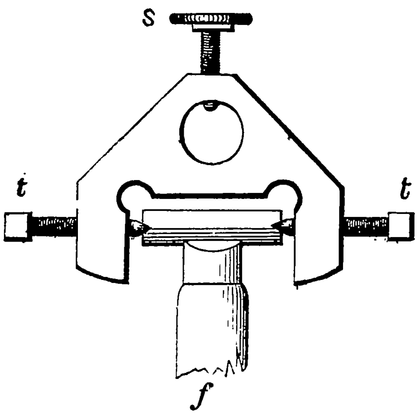
Each of these pins has a notch cut in the middle, of the

form which would result from placing the vertices of two cones together. By this arrangement, there can be no loss of motion; besides, it affords great facility in changing the rod from one pin to another.

The rod (f) is connected with the clamp arm by dropping the notch (z), fig. 2, on one of the pins.

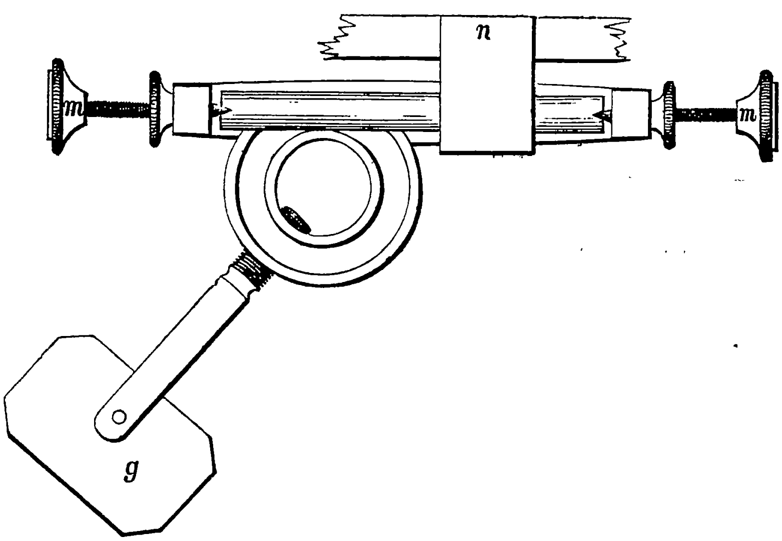
The other end of the rod is attached to the lever (l), fig. 1. A sectional view of the mechanism for this purpose is

Fig. 3.



seen in fig. 3; (t, t), being two screws having conical points, (s) a set screw for clamping to (l).

Fig. 4.



The pencil arm shown at (c), fig. 1, is attached to the lever (b), by an arrangement precisely similar to that seen in fig.

3, the pencil being held above the paper by a flat spring placed underneath.

The lever (*b*) is supported on the horizontal post (*e*), fig. 1; *g* is a set screw for clamping to any part of the post (*e*); *h* and *i* are weights for counterpoising the lever in any position.

The supporting axis of *b* is seen in fig 4, where *m*, *m*, are two screws having conical points. By this arrangement, we avoid all loss of motion, and have but very little friction.

In fig. 1, *k* is an electro-magnet operating the arm (*d*), at the end of which, and parallel to the axis of the cylinder, is attached the cross piece *j*.

The dials seen in fig. 1 indicate minutes and seconds.

Now, when the Telescope is moved in zenith distance, motion is given to the pencil so that it moves over the cylinder in the direction of its axis. Whenever we wish to make a record, a key is pressed which closes the circuit through the electro-magnet, and a blow is struck on the pencil arm, so that a small dot is made on the sheet of paper covering the cylinder.

As fast as the stars enter the field of the Telescope, they are brought to the intersection of a horizontal and vertical wire, when, the circuit being closed, the record is made. In this way, the position of the stars in the heavens are transferred to the surface of the cylinder, so that when our observations are finished, we have a perfect "*fac simile*" copy of the zone of stars observed.

With this apparatus, we have the *first* accurate record of Right Ascension and Declination made at the same time, by mechanical means. When the dot is made on the cylinder, a record is also made on the working Chronograph, which gives us the time to the hundredth part of a second. For the exact declination, an assistant reads the Declinometer scale to the five-tenths of a second.

Therefore, when our zone is observed, we have not only

a complete catalogue of the exact positions of the stars, but also a perfect map of the heavens.

In case we do not read our Declinometer scale, we can determine the declination from the chart, within one-tenth of a minute of arc. The precision with which this machine will map stars is all that could be desired; since if two charts of the same zone, made on different nights, be placed one over the other, the stars will be superimposed so that the eye can detect no difference.

By means of movable adjustments, we can set the machine (having our sheet ruled for Right Ascension and Declination), so that it will give the position of the zone, at the beginning of the year, without sensible error. For adjusting in Right Ascension, the cylinder can be moved about its axis, being held in position by a friction block. For the declination, we lengthen or shorten the rod (f), by means of the screw (x), fig. 2. The scale for declination can be varied at pleasure, by changing the position of the connecting rod (f), on the lever l, fig. 1. This apparatus can be adapted to any Telescope either transit or equatorial; neither does its use interfere with the ordinary work for exact positions.

In the observation of Asteroids on the meridian, a great deal of time is wasted, especially when the error of the Ephemeris is considerable. And even when the error is only $2'$ or $3'$ in declination, in certain portions of the heavens, it is almost impossible to find the body with a meridian instrument. We believe it is a rule adopted by Prof. Airy, the Astronomer Royal, to observe only those Asteroids whose places are pretty accurately known.

This apparatus affords great facility in finding these bodies, when we have an approximate Ephemeris; since it is only necessary to observe, on two nights, a short zone of five minutes in Right Ascension and 10 minutes in Declination. The comparison of these two charts will at once show which is the planet, provided it is included within

those limits; when, the Ephemeris being corrected, it can be observed on the meridian in the usual way. This has already been tested in finding some of the old Asteroids, using for our Ephemerides Hind's Supplement to the Nautical Almanac.

In our ordinary work, as we observe all stars visible, the limit being 13-14 magnitude, it is usually impracticable to observe a zone of greater width than 10′ or 12′; and within these limits, it is not unusual to find more than 200 stars in one hour of Right Ascension. The magnitudes of the stars observed are recorded on the Chronograph, by striking a certain number of dots for each magnitude. This, however, is not absolutely necessary, since the assistant in reading the Declinometer scale records, at the same time, the number of the star and the magnitude, and, to guard against error, occasionally the time of transit.

In order, however, that the apparatus may be complete within itself, we propose to attach a mechanism so that the observer can record, with type or otherwise, the magnitudes in their regular order.

In case we wish to extend our observations over more than one hour of Right Ascension, we loosen the clamp screw (*g*), fig. 1, and slide the whole apparatus carrying the pencil, on the post *e*; the end of the connecting rod (*f*) being raised up and dropped on another pin. These changes can all be made in less than one minute.

In our zone work with this apparatus, we have observed and charted 300 stars in a single hour. But generally we consider 200 as the maximum number that can conveniently be observed in that time; since, in the latter case, greater accuracy can be attained, which is more to be desired than multiplicity of observations.

Having given a general outline of the plan adopted in making charts of zone stars, it may now be desirable to state some of the possible advantages resulting from the use of this method.

Every one will at once see, that a series of charts, even in the condition in which they are taken from the cylinder, will be of great value to the observatory in which they are made. For, after being numbered and filed, they become so many maps, although the width does not exceed 10 minutes of arc. But obviously they can be made of greater service, with but little additional labor, by transferring contiguous zones to one sheet. This is easily accomplished by merely pricking through the paper, with a series of points which shall at once indicate the magnitudes.

In case we wish to search for Asteroids, we believe much labor can be saved, and equal if not greater facility afforded in their discovery. For, suppose we have already completed a series of charts for one hour of right ascension, and one degree declination, it is only necessary to observe and map the same zone, or any portion of it; when it is readily seen, should there be any Asteroid in that region which was not there when the former charts were made, it will at once be detected.

The objection may be offered, that with the ordinary meridian instruments, we do not have optical power sufficient to detect these faint bodies. Granting this to be the case, it does not affect the principle of the method, for we can use the apparatus with an equatorial of any size. In the latter case, we would clamp the Telescope securely in the meridian, and, attaching an arm to the declination axis, at once connect our apparatus in the same manner as with the transit. Slow motion in declination can now be given to the Telescope with the tangent screw, and the width of the zone limited by employing any mechanism suitable to the instrument. These minor details, of course, will be arranged by the observer, as circumstances require. We know that an equatorial can successfully be used in differential work, by this method, as has been abundantly verified in the use of the Cincinnati equatorial, which has an aperture of 12 inches and focal length of 17 feet.